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SATELLITE MICROWAVE STUDIES  
OF EXPLOSIVE CYCLOGENESIS  
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## Scientific Objective

Using a combination of satellite microwave images of moisture fields in midlatitude oceanic cyclones and corresponding conventional gridded analyses of pressure, temperature, geopotential height and humidity, attempt to further clarify the role of moist processes, including latent heat release, in the occurrence of explosive cyclogenesis.

## Progress Report

This report summarizes work accomplished or in progress during the third year of a three year grant.

During the first year of the grant, we began assembling the raw data sets, developing software, and refining and testing relevant analytical techniques required. During the second year, we began the analysis of a relatively large ensemble (23 cases) of oceanic extratropical cyclones which were observed one or more times by the Special Sensor Microwave/Imager (SSM/I) during 1987 and 1988.

During the present year, we have now concluded an initial statistical analysis of the correlation between storm deepening rates and precipitation parameters derived from SSM/I data, in which we found a striking correlation ( $r \approx 0.8$ ) between satellite-derived rain intensity and 12 hour central pressure change in 31 overpasses of 23 deepening cyclones. The results of this analysis have been accepted for publication in *Monthly Weather Review*. (Petty and Miller 1995). It was also presented as an invited paper at the 7th AMS Conference on Satellite Meteorology and Oceanography in Monterey.

In support of a more detailed analysis of the role of moist processes in oceanic cyclogenesis, , Ph.D. student Douglas K. Miller has been using the NCAR/PSU Mesoscale Model (MM4) to run 48-hour simulations of the cyclones in our data base. These simulations are now essentially complete. Post-processing of the model output, followed by detailed comparisons of the model fields with 29 SSM/I snapshots of precipitation and water vapor distributions in the storms, represents the final phase of Doug Miller's dissertation work, to be completed during the coming year.

Techniques used in the MM4 post-processing software (e.g. filtering, estimates of important physical forcings) are being tested for accuracy and dependability. Once tests have been concluded satisfactorily, model output of the 23 storms will be processed so that we will have a time series, at each vertical level of the model in the vicinity of the surface cyclone, of various dynamic and thermodynamic forcing mechanisms contributing to the deepening rate. We thus hope to document the physical mechanisms contributing to the above noted correlation.

Model output will also give us a three-dimensional view of dynamic and moisture fields at times that coincide with SSM/I overpasses. Our hope is that the model might help to explain vertically integrated moisture features observed by the SSM/I and, also, that the SSM/I might point to inadequacies in the model which could assist in improving simulations of extratropical cyclones.

Several other papers authored or co-authored by the PI have also been published during the past year (see list at end); however these are attributed to another NASA grant

(NAGW-3944) on account of their emphasis on algorithm development work rather than on the application of microwave data to the study of storm dynamics. They nevertheless represent advancements in the PI's rain rate retrieval work that bear directly on the utility of the SSM/I data in the present cyclone studies.

### **Remarks Concerning Conclusion of Project Period**

The period of funding covered by this 3-year grant ends April 30, 1995. Because student Doug Miller received a NASA Graduate Student Research Program (GSRP) fellowship that covers his stipend, registration fees, and some expenses until his Ph.D. completion date (tentatively August 1995), we anticipate being able to continue work on this project, under a 1-year no-cost extension, until the funds from both the GSRP and this grant have expired. A final report for the grant will then include Mr. Miller's dissertation, as well as one or more additional manuscripts submitted for publication in a refereed journal.

A proposal will soon be submitted requesting new funding from NASA; however, the new proposal will address a different research area than we have previously pursued under the current grant.

### **Relevant activities and accomplishments during project year**

- Five conference papers presented at the 7th AMS Conference on Satellite Meteorology and Oceanography, including one invited paper (presented orally by student Doug Miller) on results from the current project.
- SSM/I rain rate algorithm products were submitted to the Second Precipitation Intercomparison Project (PIP-2) and to the 3d Algorithm Intercomparison Project (AIP-3).
- PI attended the NASA Annual Research Review in Huntsville, Alabama (June, 1994).
- PI appointed co-chair of the upcoming 8th Conference on Satellite Meteorology and Oceanography.

### **Relevant new Journal Publications by the PI ("\*" indicates publications explicitly supported by NASA grant NAG8-918)**

Petty, G.W., 1994: Physical retrievals of over-ocean rain rate from multichannel microwave imagery. Part I: Theoretical characteristics of normalized polarization and scattering indices. *Meteorol. Atmos. Phys.*, **54**, 79-100 (invited paper)

Petty, G.W., 1994: Physical retrievals of over-ocean rain rate from multichannel microwave imagery. Part II: Algorithm implementation. *Meteorol. Atmos. Phys.*, **54**, 101-122 (invited paper)

Wilheit, T., R. Adler, S. Avery, E. Barrett, P. Bauer, W. Berg, A. Chang, J. Ferriday, N. Grody, S. Goodman, C. Kidd, D. Kniveton, C. Kummerow, A. Mugnai, W. Olson, G. Petty, A. Shibata, E. Smith, R. Spencer, 1994: Algorithms for the retrieval of rainfall from passive microwave measurements. *Remote Sens. Rev.*, **11**, 163-194

Barrett, E.C., R.F. Adler, K. Arpe, P. Bauer, W. Berg, A. Chang, R. Ferraro, J. Ferriday, S. Goodman, Y. Hong, J. Janowiak, C. Kidd, D. Kniveton, M. Morrissey, W. Olson, G. Petty, B. Rudolf, A. Shibata, E. Smith, R. Spencer, 1994: The first WetNet Pre-

- precipitation Intercomparison Project: Interpretation of results. *Remote Sens. Rev.*, **11**, 303–373
- Petty, G.W., 1995: The status of satellite-based rainfall estimation over land. *Remote Sens. Environ.* (to appear in Jan. issue), 13 pp. (invited paper)
- \* Petty, G.W., and D.K. Miller, 1995: Satellite microwave observations of precipitation correlated with intensification rate in extratropical oceanic cyclones. *Mon. Wea. Rev.* (in press)
- Petty, G.W., 1995: Frequencies and characteristics of global oceanic precipitation from shipboard present-weather reports. *Bull. Amer. Meteor. Soc.* (to appear in September issue)

### Relevant New Conference Papers

- Petty, G.W., and D.R. Stettner, 1994: A new inversion-based algorithm for retrieval of over-water rain rate from SSM/I multichannel imagery. *7th Conference on Satellite Meteorology and Oceanography*, Monterey, California, 6–10 June. (Oral presentation)
- Petty, G.W., A. Mugnai, and E.A. Smith, 1994: Reverse Monte Carlo simulations of microwave radiative transfer in realistic 3-D rain clouds. *7th Conference on Satellite Meteorology and Oceanography*, Monterey, California, 6–10 June. (Poster presentation)
- Petty, G.W., 1994: Some regional characteristics of oceanic rainfall and their implications for satellite rainfall retrievals. *7th Conference on Satellite Meteorology and Oceanography*, Monterey, California, 6–10 June. (Poster presentation)
- Petty, G.W., and M.D. Conner, 1994: Identification and classification of transient signatures in over-land SSM/I imagery. *7th Conference on Satellite Meteorology and Oceanography*, Monterey, California, 6–10 June. (Poster presentation)
- \* Petty, G.W., and D.K. Miller, 1994: SSM/I rainfall indices correlated with deepening rate in extratropical cyclones. *7th Conference on Satellite Meteorology and Oceanography*, Monterey, California, 6–10 June. (invited paper, oral presentation by D. Miller)